Exercise 1. Consider the binary knapsack set $K = \{x \in \{0,1\}^n : a^T x \leq b\}$ with $0 < a_j \leq b$ for all $j \in \{1, \dots, n\}$. Show that $x_j \geq 0$ defines a facet of $\text{conv}(K)$.

Exercise 2. Find minimal cover inequalities for the set

$$\{x \in \{0,1\}^7 : 11x_1 + 6x_2 + 6x_3 + 5x_4 + 5x_5 + 4x_6 + x_7 \leq 19\}.$$

Exercise 3. Consider the knapsack problem:

$$\begin{array}{ll} \max & 2x_1 + 5x_2 + 3x_3 + x_4 + x_5 \\ \text{s.t.} & x_1 + 4x_2 + 3x_3 + 2x_4 + 2x_5 \leq 7 \\ & x_1, \dots, x_5 \in \{0,1\} \end{array}$$

a) Find the optimum x^* of the linear relaxation and use it to construct a minimal cover inequality.

b) Use lifting to strengthen the cut and solve the relaxation of the new problem.

Exercise 4. Apply the following heuristics to the symmetric TSP given by the cost matrix

$$\begin{pmatrix} - & 8 & 4 & 9 & 9 \\ 8 & - & 6 & 7 & 10 \\ 4 & 6 & - & 5 & 6 \\ 9 & 7 & 5 & - & 4 \\ 9 & 10 & 6 & 4 & - \end{pmatrix},$$

a) nearest neighbor,

b) greedy algorithm,

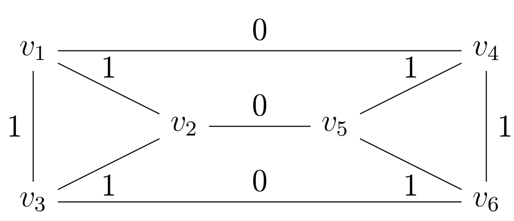
c) savings heuristics,

d) nearest insertion,

e) minimum spanning tree method,

f) 2-change method.

Exercise 5. Consider a TSP instance on the graph



where the cost of a missing edge is equal to the shortest path between the two nodes. Find a comb inequality cutting off the fractional solution

$$x_{14} = x_{25} = x_{36} = 1,$$

$$x_{12} = x_{23} = x_{13} = x_{46} = x_{56} = x_{45} = \frac{1}{2},$$

(other values are 0).

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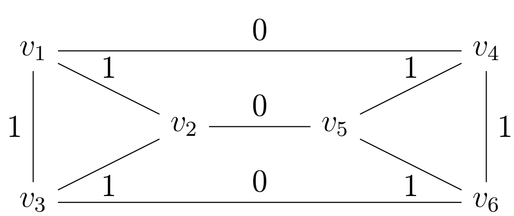

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